

The University of Chicago

FACTORS AFFECTING THE LEGIBILITY OF HANDWRITING

A PART OF A DISSERTATION SUBMITTED TO THE FACULTY
OF THE DIVISION OF THE SOCIAL SCIENCES IN CANDIDACY
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATION

1944

By

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LESLIE QUANT
Social Security Board
Washington, D. C.

PREFATORY NOTE

The paragraphs of handwriting which constitute the reading selections used in this study have been omitted in this printing, but may be found in the complete dissertation in the library of the University of Chicago.

INTRODUCTION

THE PROBLEM

The investigation here reported is an attempt to show how various factors modify the legibility of handwriting. The data are derived from an objective study of the eye-movements of subjects as they read paragraphs of handwriting. In this study legibility is considered as synonymous with readability. Legibility is not considered as a unitary characteristic, but is regarded as a composite made up of simpler elements. Dr. Frank N. Freeman in his *Chart for Diagnosing Faults in Handwriting*,¹ has selected five characteristics for measuring the quality of handwriting: (1) letter formation, (2) spacing, (3) alinement, (4) slant, and (5) quality of line. The present study will be organized around these characteristics.

As far as the writer has been able to discover, no previous attempt has been made to show how these characteristics enter into the legibility of handwriting. Investigators in the field have assumed that handwriting that presented a good appearance was legible, but no attempt has been made objectively to analyze handwriting to see how any of the factors which Freeman studied determines the legibility of a selection of handwriting. Breed and Culp² conducted an investigation to determine the relationship between legibility (quality of handwriting) and speed, based on the Ayres Handwriting Scale. They later suggested a weighting³ for factors in the form of

¹ Frank N. Freeman, "An Analytical Scale for Judging Handwriting," *Elementary School Journal*, XV (1915), pp. 432-441.

² Frederick S. Breed and Vernon Culp, "An Application and Critique of the Ayres Handwriting Scale," *School and Society*, II (1915), pp. 639-647.

³ Frederick S. Breed and Vernon Culp, "Note on the Relation of Legibility and Form in Handwriting," *School and Society*, IV (1916), p. 872.

handwriting which make for legibility. The Pressey's made an investigation of the illegibilities in handwriting, in which persons who read the material were asked to note any letter formations that gave any trouble in reading. Illegibilities were checked by the criterion⁴ that "if they (the subjects) had to look twice at a word, they were to check that part of the word which gave them trouble."

In the present study each factor is considered separately from the other factors, in an attempt to determine the relative importance of each in the total composite which is called good writing or poor writing on the basis of legibility. The ease with which the handwriting can be read is to be considered through an attempt to answer the following questions:

1. What effect, if any, do variations in letter formation have on legibility of handwriting?
2. What effect, if any, does variation in spacing have on legibility of handwriting?
3. What effect, if any, does irregularity of alinement have on legibility of handwriting?
4. What effect, if any, does irregularity of slant have on legibility of handwriting?
5. What effect, if any, does the quality of line have on legibility of handwriting? (Quality is used here in a restricted sense, and refers to the weight of the line of writing.)

PROCEDURE

Derivation of the handwriting selections.—As a preliminary step the author observed the handwriting of numerous persons, in order to discover very good and very poor quality of handwriting. These individuals were then asked to vary their habitual manner of writing in certain respects. For example, a person who wrote with good alinement of letters was asked to write exactly as he would write normally, except that he would use poor alinement. If the individual wrote with poor letter formation, he was asked to improve this characteristic so that his writing would be

⁴ Luella C. Pressey and Sydney L. Pressey, "Analyses of Three Thousand Illegibilities in the Handwriting of Children and Adults," *Educational Research Bulletin*, VI (September 27, 1927), p. 270.

changed only by having good letter formation. Otherwise his writing was not to be changed in any respect. Repeated trials with a large number of persons, both good and poor writers, showed that modification of one characteristic of handwriting results in some degree of accompanying changes in other characteristics also. If a person writes habitually with even slant, and then attempts to write with uneven slant, he alters the letter formation, writes with uneven alinement, or even changes the quality of line, and modifies the spacing between letters. This method of deriving samples of handwriting which would be comparable in all respects except one selected characteristic was finally abandoned as impracticable.

The next step was an investigation of a large number of samples of handwriting in an effort to locate, if possible, certain "types" of handwriting. Prospective Freshman students at the University of Chicago formerly were asked to submit, as a part of their personnel record, an autobiography in their own handwriting. A careful search through approximately 750 of these records revealed the fact that there are no "types" of handwriting. On the contrary, handwriting shows a great variety of individual differences from person to person. The poor handwriting in these records was usually poor in several respects, and the good writing was good in most respects. All possible variants of good and poor seemed to be present in numerous combinations. The attempt, therefore, to select samples of "typical" handwriting was likewise considered futile.

The author next selected a paragraph, designated in this study as Selection 2, produced in his habitual style of writing, with a medium-point fountain pen. After a period of intensive practice the writer found it possible to modify his own handwriting so that other selections could be written similar to Selection 2 in all respects but one. For example, one paragraph was written in which the letter formation was poor, but in all other respects (spacing, slant, etc.) the writing was of the same quality as the original paragraph (Selection 2).

In order that the difficulty of the content of the selections would remain constant throughout the study, the standardized paragraphs—"Peter's Dream"—were used.⁵

⁵ These paragraphs were devised by Dr. W. S. Gray for testing oral reading ability.

The following selections were read by the subjects participating in this investigation:

Selection 1—a printed paragraph.

Selection 2—a paragraph of normal handwriting in the author's habitual style of writing.

Selection 3—handwriting with poor letter formation.

Selection 4—normal handwriting, but with reduced spacing between letters and between words.

Selection 5—normal handwriting with reduced spacing between letters, but with normal spacing between words.

Selection 6—normal handwriting, but with the spacing reduced to $\frac{1}{4}$ inch between the lines of writing.

Selection 7—normal handwriting, but with increased spacing between letters and between words.

Selection 8—a paragraph written with uneven alinement of letters.

Selection 9—a paragraph written with irregular slant.

Selection 10—a paragraph written with a heavy line.

Selection 11—a paragraph written with a light line.

Plates I to XI show the paragraphs used for this study. Selections 2 to 11 have been reproduced by mimeograph, and the lines of all selections have been separated vertically for ease of plotting the photographic records of eye-movement during the reading.

Further description of these experimental paragraphs of handwriting will show the extent to which they vary from the original paragraph of normal handwriting (designated as Selection 2).

Table I shows that Selection 2, with a total of 155 letters, has 148 letters that may be classified as having good letter formation—95 per cent of the total number. There is no objective standard by which letter formation can be judged to be poor or good, since the different handwriting systems in general use are not in perfect agreement, but in this study, any departures from accepted good form have been the criterion by which a letter is said to have poor form. As examples, failure to close the loop of the "a", "d", or "o", "m" and "n" which are not rounded at the top of the strokes, failure to complete the loop of "b", "g", "h", "j", "l", and "y", in-

TABLE I
LETTER FORMATION IN SELECTIONS 2 TO 11*

Selection	Number of Letters with Good Formation	Number of Letters with Poor Formation	Total Number of Letters	Per Cent of Good Letters	Per Cent of Poor Letters
2-----	148	7	155	95	5
3-----	25	127	152	16	84
4-----	160	4	164	98	2
5-----	126	5	131	96	4
6-----	125	7	132	95	5
7-----	138	7	145	95	5
8-----	138	9	147	94	6
9-----	140	5	145	97	3
10-----	128	6	134	96	4
11-----	134	4	138	97	3

* Data are not included for Selection 1, since it is printed material.

correct formation of "r", "w", "v", confusion of "i" and "e", or of "a" and "o", or any malformation of a letter—all these indicate the basis on which letters have been judged as having poor formation. Comparison of the data in Table I shows a high degree of uniformity of all paragraphs with respect to letter formation—varying from 94 per cent to 98 per cent except for Selection 3—the paragraph which was written expressly to provide a selection characterized by poor letter formation. Selection 3, with a total of 152 letters, contains 127 letters—84 per cent—that are classified as having poor formation.

Selections 4 to 7 differ from Selection 2 (Normal Writing) with respect to the spacing. Dividers were used to measure the space between each letter and between each word in every selection of handwriting. Table II shows the average spacing between each letter and between each word in Selections 2 to 11.

TABLE II
AVERAGE SPACING BETWEEN WORDS AND BETWEEN LETTERS IN SELECTIONS 2 TO 11
(IN UNITS OF SIXTEENTHS OF AN INCH)

Selection	Average Spacing (in $\frac{1}{16}$ inch)	
	Between Words	Between Letters
2-----	3.4	1.4
3-----	3.8	1.6
4-----	3.1	0.7
5-----	1.2	0.8
6-----	4.0	1.9
7-----	5.2	2.9
8-----	3.1	1.8
9-----	3.1	1.8
10-----	3.0	1.5
11-----	3.5	1.5

Selection 4 was written in the author's normal handwriting, but the spacing was greatly reduced between the letters in each word. However, the spacing was normal between each word. In Selection 5 the spacing was greatly reduced between letters and also between the words of the paragraph. Table II shows that the average spacing between words is 3.1 sixteenths of an inch, and 0.7 sixteenths of an inch between letters for Selection 4, and 1.2 sixteenths between words, and 0.8 sixteenths of an inch between letters for Selection 5, compared to 3.4 and 1.4 between words and letters, respectively, for Selection 2 (Normal Handwriting).

Selection 6 was written in normal handwriting, but the space between lines was reduced to $\frac{1}{4}$ inch, to discover whether this reduction would affect the legibility of the selection. The spacing between letters and between words for Selection 6 is 4.0 sixteenths and 1.9 sixteenths, respectively.

In Selection 7 the spacing was increased between words and between letters, and the average space between words and between letters is 5.2 sixteenths and 2.9 sixteenths, respectively—the greatest average spacing for the entire group of selections.

Selection 8 was written in such a manner that a large number of the letters would have uneven alinement. A letter is considered to be imperfectly alined if it does not extend to the horizontal line of writing (except letters like "g", "j", and "y", parts of which normally extend below the line). Guide lines, drawn on thin paper, were placed over the selections of writing in order to discover which letters were imperfectly alined. Table III shows data for alinement for Selections 2

TABLE III

ALINEMENT OF LETTERS IN SELECTIONS 2 TO 11

Selection	Number of Letters			Total	Percentage		
	Above Line	Below Line	On Line		Above Line	Below Line	On Line
2-----	10	0	167	177	6	0.	94
3-----	13	1	138	152	8	.6	91
4-----	5	1	158	164	3	.6	96
5-----	5	0	126	131	4	0.	96
6-----	10	0	123	133	8	0.	92
7-----	9	3	133	145	6	2.	92
8-----	24	57	66	147	16	39.	45
9-----	17	2	126	145	12	1.	87
10-----	9	0	125	134	7	0.	93
11-----	7	0	131	138	5	0.	95

to 11. This table shows that the amount of properly alined letters varies from 87 per cent for Selection 9, to 96 per cent for Selections 4 and 5, except for Selection 8 (poor alinement) in which only 45 per cent of the letters show proper alinement, with 16 per cent of the letters written above the line, and 39 per cent below the line.

Selection 9 was written in the author's usual style except that the slant was varied. A protractor was used to measure the angle of slant (with the base line of writing) of all the letters in Selections 2 to 11. There is no standard slant that is considered "correct" for handwriting, but experts are in agreement that the slant should not exceed 30 degrees from vertical with the base line.⁶ Regularity of slant is considered more important in writing than is the degree of slant. Table IV presents data for each selection of handwriting in this study, and shows the amount of variation of slant for the letters in Selection 9, compared with all other selections.

Selection 10 was written with the heaviest writing pen available—Esterbrook #788. Writing was done with heavier lettering pens, but the ink did not spread uniformly on the paper, and unsatisfactory records resulted, except when the size of the writing was appreciably increased.

Selection 11 was written with the finest writing pen available—Spencerian #1. Fine lettering pens were tried, but the records produced by their use showed great variation in the width of the line, and the use of pens finer than Spencerian #1 changed markedly the quality of the handwriting.

In Freeman's studies of handwriting he uses "quality of line" to refer to "evenness

in the thickness of the line and to smoothness as distinguished from waviness."⁷ In the present study "quality of line" will be used in a more restricted sense, and Selections 10 and 11 are studied to determine how the use of a light or heavy line in writing affects the legibility of the writing, compared to the use of a line of medium weight.

APPARATUS AND TECHNIQUE

Legibility might be measured by the distance at which it is necessary to place the material so that it may be read at a stated rate with given accuracy. Degree of legibility may be measured also by the rate and accuracy with which the material can be read at a given distance. The latter method was chosen for this study. The subjects were asked to read paragraphs of handwriting, and a photographic record of eye-movements was made by means of a camera equipped with 35 mm. motion picture film.

The technique of recording eye-movements by means of photographs is sufficiently familiar not to require extended description here. The reader is referred to a detailed account of the technique presented by C. T. Gray in his monograph.⁸ The subjects read under favorable conditions, unaffected by distracting influences. Before reading, the camera and the equipment were explained to those subjects for whom the laboratory was unfamiliar. A large number of the subjects were students in the Department of Education to whom the eye-movement apparatus was already familiar. The subject and the

⁷ Frank N. Freeman and Mary L. Dougherty, *How to Teach Handwriting* (Boston: Houghton Mifflin Company, 1923), p. 170.

⁸ C. T. Gray, *Types of Reading Ability as Exhibited Through Tests and Laboratory Experiments*, Supplementary Educational Monographs, Vol. I, No. 5 (Chicago: University of Chicago Press, 1917), pp. 83-90.

⁶ Frank N. Freeman, *The Teaching of Handwriting* (Boston: Houghton Mifflin Company, 1915), p. 99.

TABLE IV

ANGLE OF SLANT OF LETTERS (WITH BASE LINE OF WRITING) FOR SELECTIONS 2 TO 11

Angle (in degrees)	Frequency for Each Selection									
	2	3	4	5	6	7	8	9	10	11
114								1		
107								1		
105								2		
103								3		
102								1		
101								1		
100								3		
97								1		
96								1		
95							1	3		
94								1		
93		1						2		
92		2						6		
91		1						7		
90	1	3	1	1	1	2		15		2
89	2					1		5		
88	1	1	1		2		3	6		
87	3	8	5	1	8	7	7	13	2	1
86	1	6	4	2	4	5	7	3		1
85	27	2	8	3	14	9	20	8		12
84	2		3	2	5	8	4	3	2	16
83	12	14	11	13	23	14	37	1	18	6
82	7	16	16	13	22	14	16	2	14	5
81	9	5	10	13	10	4	1		8	32
80	21	25	30	30	17	19	22	3	27	12
79	17	17	12	6	7	10	1	2	2	30
78	21	15	19	14	9	16	20	10	28	6
77	1	13	12	18	8	8	1	5	2	
76	8	2	10	5	2	13		6	5	8
75	17	7	10	5	1	7	3	3	11	5
74			4	2		4		5	6	2
73	2	12	5	2		2	1	6	1	
72		2	1	1		2	3	2	3	
71	1							4	1	
70			1					1	4	
69								1		
68			1							
67								1		
66								3		
65										
64										
63								2		
55								1		
54								1		
Total	12292	12198	13059	10442	10897	11652	12060	12200	10577	11024
No. of Letters	153	152	164	131	133	145	147	145	134	138
Mean	80.3	80.2	79.6	79.7	81.9	80.3	82.0	84.1	78.9	79.9

experimenter were alone in the room during the reading, and there were no disturbing factors to modify the performance of any subject.

The subjects were asked to read through the paragraph once, silently, in their accustomed manner of reading any material that they wished to remember. They were told that at the end of the reading of each paragraph simple questions would be asked to test how well the reading had been done. The questions were not standardized, but were de-

signed only as an incentive for the subjects to read the selections with care. No comment was made, either favorable or unfavorable, on the answers that the subjects gave to questions, since the experimenter did not wish to influence the performance of the subjects by introducing any factors extraneous to the reading of the material.

Before beginning the reading of each paragraph the subject was asked to "close your eyes as soon as you have finished the last line." The precaution precluded the possibil-

ity of additional eye-movements back over the material which had already been read.

The developed films were placed in a projector, and the enlarged image of the eye-movements was adjusted exactly to fit the length of the line of handwriting of each selection. The eye-movements for each subject for each selection were plotted. In this manner an exact record was obtained for each subject of the number, location, and duration of every eye pause during the reading of each paragraph.

SUBJECTS

Adults were selected as subjects for this study, on the assumption that the reading of handwriting is more largely an activity of adults than of children. The subjects were selected at random, on the basis of availability. Many were University students, both undergraduates and graduates. Some records were discarded owing to the fact that the subjects wore glasses habitually, and the necessity of reading without glasses before the camera modified the reading to so large an extent that the eye-movement record obtained did not show typical reactions for the subject. The records of 35 subjects were used—11 women and 24 men. Twenty subjects read the entire series of eleven selections. Selection 3 (poor letter formation) and Selection 7 (wide spacing between letters and between words) consistently produced a marked change in the character of reading for all subjects. Hence, these selections were omitted from the reading performance of the remaining fifteen subjects for this study.

THE READING OF PRINTED MATERIAL

The paragraph of printed material (Selection 1) was used in order to get a measure of the reading ability of the subjects. The lines of print in this paragraph are shorter than the lines of handwriting used in the other paragraphs used in this study. In the process of reading printed material the eye covers less distance in the line, but encounters more words per line than in the handwriting selections. The printed characters have more uniformity than those in handwriting. The reaction which readers make to printed material is known; hence, we may discover, through examination of the records of the subjects for the printed material whether the subjects are effective or ineffective readers.

We can then compare the performance of these subjects as they read paragraphs of handwriting. Apparent differences between a subject's reading records for the printed material and the handwriting selections may be accounted for by the variation between the printed and the written paragraphs. It can be determined at what point the reader may be experiencing difficulty if a study of eye-movements is made as he proceeds from paragraph to paragraph. Since the difficulty of the content of the paragraphs of handwriting is constant, any variation in the reading records for any subject from paragraph to paragraph can be assigned to factors in the handwriting itself, rather than to the difficulty of the content of the paragraphs.

In the plates presented in this study the vertical lines show the location of fixations of the eye during the reading. While the eye is at rest the reader perceives material both to the right and left of the fixated position. A large number of vertical lines indicates numerous pauses, and a small number indicates few pauses during the reading. The wider the eye-span the fewer the pauses (or fixations) per line; vice versa, the narrower the eye-span the greater the number of pauses, in order that the reader may perceive the material. The numbers above the vertical lines indicate the order in which the pauses were made within the line. The numbers below the vertical lines show the duration of the pauses, measured in units of twenty-fifths of a second.

The difference between effective and ineffective reading can be determined by a study of the eye-movement records. Effective reading has relatively few fixations per line. Five to six should be sufficient for a line of print such as is found in Selection 1. If the subject has mature reading habits, these fixations should be more or less regularly spaced within the lines, because mature reading is characterized by rhythmical movements of the eyes along the line of print. The immature reader, on the other hand, fixates frequently, and the distance between the fixations within the line is likely to show irregularity. Frequent fixations in the line indicate that it is necessary for the reader to break up the line of print into small units in order to comprehend the material. The necessity for small units may be accounted for by the form of the material, or may be occasioned by the

difficulty of the content. The presence of a large number of fixations is evidence, therefore, that the reader is encountering difficulty, either on account of the form, or because the content is difficult to comprehend. The subject who has developed mature reading habits shows little variation in the duration of the pauses. The fixations are not altogether uniform, but the variation in the duration of the fixations is not marked. If a reader encounters anything unusual in the reading process he may involuntarily increase the duration of the fixations in order more deliberately to perceive the material. In effective reading of ordinary easy material such as Selection 1 pauses of unusual length should be infrequent.

Another characteristic of effective reading is the regularity of eye-movement from left to right. If the subject has developed good reading habits the eye moves along the line from the beginning to the end in a series of short movements, followed by a long return sweep of the eye to the left to the beginning of the next line. An occasional regressive movement back toward the left is not unusual even in effective reading, especially near the beginning of lines. These regressive movements at the beginning of lines are caused by a failure to make a long enough return sweep to carry the eye the entire distance back from the end of one line to the beginning of the following line. As the subject reads, if he encounters difficulty so that his rhythm is disturbed, he is also likely to make regressive movements in order more effectively to recognize what is printed in the line. The control of the eye, in an attempt to hold it in one position for any great length of time, is difficult, and for this reason, when a subject pauses for a considerable period of time at any point in the reading, the record is likely to show not one long fixation, but rather a series of separate movements, shifting irregularly backward and forward along the line. The subject who has failed to develop good reading habits will manifest this shifting tendency of the eye to a much more marked degree than will the subject who has developed good habits. A large number of regressive movements means that the reader is encountering difficulty in his reading.

These characteristics of eye-movements in reading will be more apparent if a comparison is made between the records of the most effective and of the least effective readers among

the subjects used in this study. The record of an effective reader shows a relatively large average number of words per fixation, the duration of the fixations is short, and the average number of words per regressive movement is large. Ineffective readers have a relatively small number of words per fixation, the duration of the fixations is likely to show considerable variation, and the reading records are likely to show a smaller number of words per regression than in the records of effective readers.

Table V presents data for Selection 1 (Printed Paragraph) for all subjects with reference to the average number of words read per fixation, the average duration of fixations, and the average number of words read per regression.

The average number of words read per fixation for all subjects is 1.4, ranging from 0.9 for Subject 19 to 2.0 for Subject 6. The average duration of fixations in units of $1/25$ second is 6.5, with a range from 4.5 for Subject 32 to 8.6 for Subjects 1 and 5. The average number of words read per regression is 19.4, with a range from 5.7 for Subject 19 to 40+ for the six subjects whose records contain no regressive movements. It is apparent that the variation from subject to subject is not consistent for the number of words read per fixation, the average duration of fixations, and the average number of words per regression. Some subjects who are effective readers may have a high average number of words per fixation, but use relatively long fixation time. Most of the subjects had few regressive movements. Subject 19, with seven regressive movements, had the largest number of the entire group.

The variation in the reading records for the entire group will be more apparent if the records of the eight most effective readers are compared with the records of the eight least effective readers.

In selecting the eight most effective readers and the eight least effective readers of the subjects used in this study the following method was used. The reading record for Selection 1—the printed paragraph—for each subject was assigned a rank order, according to each of these criteria: (1) average number of words read per fixation, with highest rank to subjects having the largest number, (2) the duration of fixations, with the highest rank to subjects having the shortest duration,

TABLE V

NUMBER OF FIXATIONS, AVERAGE NUMBER OF WORDS READ PER FIXATION, AVERAGE DURATION OF FIXATIONS, AND THE AVERAGE NUMBER OF WORDS READ PER REGRESSION FOR SELECTION 1

Subject Number	Number of Fixations	Average Number of Words Read per Fixation	Average Duration of Fixations	Average Number of Words per Regression*
1	21	1.9	8.6	10.0
2	33	1.2	5.5	40.00
3	29	1.4	7.7	8.0
4	27	1.5	6.0	40.0+
5	26	1.5	8.6	40.0
6	20	2.0	5.5	40.0
7	22	1.8	7.8	40.0
8	26	1.5	6.1	40.0
9	31	1.3	5.0	20.0
10	23	1.7	6.9	40.0+
11	24	1.7	6.5	40.0
12	31	1.3	5.9	40.0
13	36	1.1	6.1	8.0
14	21	1.9	8.5	20.0
15	26	1.5	6.5	40.0
16	32	1.2	7.0	13.3
17	32	1.2	7.3	40.0
18	32	1.2	7.0	10.0
19	44	0.9	6.8	5.7
20	37	1.0	7.0	10.0
21	24	1.7	4.9	20.0
22	28	1.4	7.1	20.0
23	36	1.1	8.2	13.3
24	30	1.3	5.8	40.0+
25	24	1.7	6.0	40.0+
26	14	2.8	7.2	40.0+
27	28	1.4	6.8	40.0
28	27	1.5	5.5	40.0
29	33	1.2	5.5	40.0
30	34	1.2	6.0	40.0
31	34	1.2	7.4	10.0
32	29	1.4	4.5	40.0
33	34	1.2	5.1	20.0
34	26	1.5	5.4	40.0+
35	31	1.3	6.5	8.0
Total	1005			
Mean	28.7	1.4	6.5	19.4

* The records followed by plus signs in the last column are records of subjects who made no regressions in the entire selection. The plus sign indicates that the records might have been higher with a longer selection.

(3) average number of words per regressive movement, with highest rank indicating the largest number of words read per regression. The average of these three rankings was used as an index of the relative rank of each subject in the effectiveness of his reading.

On this basis Subjects 4, 6, 10, 21, 25, 26, 32 and 34 may be regarded as the eight most effective readers of the entire group, and the eight least effective readers are Subjects 3, 13, 16, 18, 19, 20, and 23.

Table VI presents data for the eight most effective readers and for the eight least effective readers in the group of subjects.

It is evident that the most effective readers are superior to the group of least effective readers in every characteristic. The most effective group shows a mean of 23.8 fixations for the paragraph, compared with 35.0 for the least effective group. In comparing the average number of words per fixation the most effective readers show a mean of 1.8 compared with 1.1 for the least effective readers. In average duration of fixations the most effective readers have a mean of 5.8 twenty-fifths of a second, compared with 7.1 for the least effective readers. A large difference exists between the two groups with respect to the average number of words per

TABLE VI

AVERAGE NUMBER OF WORDS READ PER FIXATION, AVERAGE DURATION OF FIXATIONS, AVERAGE NUMBER OF WORDS READ PER REGRESSION FOR THE MOST EFFECTIVE AND FOR THE LEAST EFFECTIVE READERS, FOR SELECTION 1

Subject Number	Number of Fixations	Average Number of Words Read per Fixation	Average Duration of Fixations	Average Number of Words Read per Regression
Most Effective Readers				
4-----	27	1.5	6.0	40.0+
6-----	20	2.0	5.5	40.0
10-----	23	1.7	6.9	40.0+
21-----	28	1.7	4.9	20.0
25-----	24	1.7	6.0	40.0+
26-----	14	2.8	7.2	40.0+
32-----	29	1.4	4.5	40.0
34-----	26	1.5	5.4	40.0+
Total-----	191	14.3	46.4	300.0
Mean-----	23.8	1.8	5.8	37.5
Least Effective Readers				
3-----	29	1.4	7.7	8.0
13-----	36	1.1	6.1	8.0
16-----	32	1.2	7.0	13.3
18-----	32	1.2	7.0	10.0
19-----	44	0.9	6.8	5.7
20-----	37	1.0	7.0	10.0
23-----	36	1.1	8.2	13.3
31-----	34	1.2	7.4	10.0
Total-----	280	9.1	57.2	78.3
Mean-----	35.0	1.1	7.1	9.8

regression, with 37.5 as the mean for the most effective readers and 9.8 for the least effective readers.

The most effective readers use fewer fixations in reading the paragraph, with a larger average number of words per fixation. They employ shorter fixation time than is found in the records of the least effective readers. They also use few regressive movements. The least effective readers invariably make regressive movements in reading Selection 1.

THE READING OF NORMAL HANDWRITING

Selection 2 may be regarded as the normal selection of handwriting for this study, since it has good letter formation, regular spacing, even alinement, uniform slant, and a medium weight of line. It will be considered as the standard for comparison with other paragraphs of written material used in the study. It has been pointed out that printed material exhibits regularity of spacing within the line.⁹ Handwriting, on the other hand, shows variation within the selection. Because it is handwriting there will necessarily be some modification in spacing (between letters and between words), letter formation will show some

⁹ Cf. *supra*, p. 14.

imperfections, the slant will lack perfect uniformity, and the variations in pressure during the writing process will result in modification in the weight of line. The eye of the reader must, of necessity, be accommodated simultaneously to these variations during the process of reading the handwriting. For this reason it is to be expected that the reading records for normal handwriting will be to some extent dissimilar to the records for the printed material.

In effective reading of printed material the eyes move from left to right along the lines, in a series of regular, rhythmic pauses. For simple material the pauses are infrequent, the duration of the fixations is short, there is considerable uniformity of distance between the fixations, and few regressive movements are present. These general characteristics of the reading of printed material show some degree of modification when the subjects read a selection of handwriting. A comparison of the reading records for Selection 1 and Selection 2 will show the extent of this modification.

Table VII shows data for all the subjects who read the paragraph of normal handwriting (Selection 2).

TABLE VII

NUMBER OF FIXATIONS, AVERAGE NUMBER OF WORDS READ PER FIXATION, AVERAGE DURATION OF FIXATIONS, AND AVERAGE NUMBER OF WORDS READ PER REGRESSION FOR SELECTION 2

Subject Number	Number of Fixations	Average Number of Words Read per Fixation	Average Duration of Fixations	Average Number of Words per Regression
1-----	41	0.9	6.3	4.7
2-----	---	---	---	---
3-----	36	1.0	7.7	7.6
4-----	37	1.0	5.7	38.0
5-----	40	0.9	6.6	12.7
6-----	29	1.3	6.0	38.0
7-----	28	1.3	6.6	38.0
8-----	31	1.2	5.0	38.0
9-----	39	0.9	5.5	19.0
10-----	32	1.2	7.6	38.0
11-----	40	0.9	5.7	9.5
12-----	33	1.1	6.7	19.0
13-----	51	0.7	6.4	3.8
14-----	32	1.2	7.0	19.0
15-----	36	1.0	6.0	7.6
16-----	32	1.2	5.4	19.0
17-----	49	0.8	6.0	7.6
18-----	45	0.8	6.5	5.4
19-----	46	0.8	6.3	3.1
20-----	46	0.8	6.9	9.5
21-----	35	1.1	4.9	38.0
22-----	---	---	---	---
23-----	44	0.8	7.5	5.4
24-----	35	1.1	6.3	19.0
25-----	23*	1.2	5.1	28.0
26-----	34	1.1	5.3	19.0
27-----	38	1.0	6.4	12.7
28-----	38	1.0	5.3	6.3
29-----	41	0.9	5.4	12.7
30-----	40	0.9	5.5	12.7
31-----	36	1.0	6.0	12.7
32-----	35	1.8	4.1	38.0+
33-----	38	1.0	5.6	7.6
34-----	40	0.9	4.7	5.4
35-----	41	0.9	5.8	7.6
Total-----	1241	---	---	---
Mean-----	37.6	1.0	6.0	10.1

* Record is for five lines.

The first difference to be noted in the reading of the two selections is that handwriting requires more eye-movements than printed material. The eye-span is narrowed in reading the paragraph of handwriting, necessitating more pauses as the subject progresses along the lines. For the entire group of subjects in reading printed material the average number of words per fixation is 1.4. In reading handwriting the average number of words per fixation for the group drops to 1.0. The difference is large enough to indicate that the handwriting presents greater difficulty to the reader than does the printed selection. This difference is consistent when the individual subjects are considered. Every subject, with the exception of Subjects 16 and 32, shows a

smaller number of words read per fixation in Selection 2 than in Selection 1. Subject 16 shows an average of 1.2 words per fixation for both selections, and Subject 32 shows an average of 1.4 words for print and 1.8 for handwriting. Subject 32 is the one subject in the group whose record for reading handwriting shows a larger average number of words per fixation for handwriting.

A second criterion by which to judge the difficulty of material is the duration of the fixations of the eye. Long durations indicate a deliberate reaction to the characters in the material being read. Table VII shows an average duration of 6.0 twenty-fifths second for the fixations for all subjects in reading handwriting, compared with the average dura-

tion of fixations of 6.5 twenty-fifths second for all subjects in reading Selection 1 (printed paragraph). In reading handwriting the subjects employ shorter pauses than in reading printed material. Instead of increasing the duration of fixations in reading handwriting the subjects use fixations of shorter duration, but they increase the number of fixations.

A third difference between the reading of handwriting and printed material is to be noted in the number of regressive movements in the records. As material increases in difficulty the subject tends to retrace the material already read in order to increase his perception. Hence, the presence of regressive movements in a reading record is indicative of difficulty, or at least of uncertainty on the part of the reader. Absence of regressive movements in a reading record is an indication that the reader finds the material easy to comprehend, without the necessity for additional backward movements in the line. Table VII shows an average of 10.1 words per regressive movement for the entire group of subjects, compared with an average of 19.4 words per regressive movement for the printed paragraph. It is evident that the reading of handwriting is more difficult than printed material, since the average number of words

per regression shows such a marked decrease below the average for the printed material—47.9 per cent.

Not only is the average number of words read per regression less for handwriting than for printed material, but the differences are consistent when the records for the two selections are compared. The records for all subjects show a smaller number of words read per regression except Subjects 21 and 31. These two subjects show a larger average number of words read per regression for the handwriting than for the printed material. It is evident that the reading of handwriting causes more regressive movements than does printed material.

These differences in the averages for the entire group between the records for the paragraph of print and the paragraph of handwriting are borne out in an examination of the records of the most effective readers, and their comparison with the records of the least effective readers. The records of both groups show a superior performance for the reading of the selection of printed material.

Table VIII shows data for the eight most effective readers and the eight least effective readers in the entire group of subjects.

TABLE VIII
AVERAGE NUMBER OF WORDS READ PER FIXATION, AVERAGE DURATION OF FIXATIONS, AVERAGE NUMBER OF WORDS READ PER REGRESSION FOR THE MOST EFFECTIVE AND FOR THE LEAST EFFECTIVE READERS, FOR SELECTION 2

Subject Number	Number of Fixations	Average Number of Words Read per Fixation	Average Duration of Fixations	Average Number of Words Read per Regression
Most Effective Readers				
4-----	37	1.0	5.7	38.0
6-----	29	1.3	6.0	38.0
10-----	32	1.2	7.6	38.0
21-----	35	1.1	4.9	38.0
25-----	23	1.2	5.1	28.0
26-----	34	1.1	5.3	19.0
32-----	35	1.8	4.1	38.0+
34-----	40	0.9	4.7	5.4
Total-----	265	9.6	43.4	242.4
Mean-----	33.1	1.2	5.4	30.3
Least Effective Readers				
3-----	36	1.0	7.7	7.6
13-----	51	0.7	6.4	3.8
16-----	32	1.2	5.4	19.0
18-----	45	0.8	6.5	5.4
19-----	46	0.8	6.3	3.9
20-----	46	0.8	6.9	9.5
23-----	44	0.8	7.5	5.4
30-----	40	0.9	5.5	12.7
Total-----	340	7.0	52.2	67.3
Mean-----	42.5	0.8	6.5	8.4

Table VIII shows a mean of 1.2 words per fixation for the most effective readers for Selection 2, compared with 1.8 words for Selection 1. The number of words read per fixation is less for the most effective readers for handwriting than for the printed paragraph. Table VIII shows that for the less effective readers there is an average of 0.8 words per fixation, compared with 1.1 words per fixation for the printed selection. For both groups of subjects the selection of handwriting was more difficult, judged by the number of words read per fixation.

An examination of the data for the average duration shows a consistent use of shorter fixations in reading handwriting than in reading the printed selection. The eight most effective readers show an average duration of 5.4 twenty-fifths second per fixation in reading handwriting, compared with 5.8 for the printed selection. The eight least effective subjects have an average duration of 6.5 twenty-fifths second per fixation for handwriting, compared with 7.1 for the printed paragraph. Both groups are consistent in the use of shorter fixations in reading handwriting.

Both the most effective and the least effective readers show a smaller average number of words read per regression for handwriting than for printed material. Table VIII shows an average of 30.3 words per regression for the most effective readers, compared with 37.5 for the same group for printed material. The least effective readers have an average of 8.4 words per regression for handwriting, compared with 9.8 words per regression for the printed paragraph. It is evident that for both the most effective and the least effective readers there is a decided increase in the number of regressive movements employed in reading handwriting, compared with the reading of printed material.

POOR LETTER FORMATION AND LEGIBILITY

Previously the reading of normal handwriting was compared with the reading of printed material. The reading records show that there is a significant difference between the difficulty of the reading of printed material and of handwriting, judged by the criteria of the average number of words read per fixation, average duration of fixations, and average number of words read per regression. The general character of the reading process is the same for printed material and for handwriting,

but there is a consistent decrease in the average number of words read per fixation, and in the average number of words read per regression for handwriting, compared with printed material. Subjects use a shorter average duration of fixations in reading handwriting than in reading printed material.

In order to determine the effect of poor letter formation on legibility it is necessary to employ a selection of handwriting that is comparable to normal handwriting in every respect, except that the letter formation shall be poor. Selection 3 is the paragraph with all the characteristics of good handwriting except good letter formation. Eighty-four per cent of the letters in Selection 3 are poorly formed.¹⁰ Any differences observed in the reading records for this paragraph, compared with the paragraph of normal handwriting (Selection 2), are to be accounted for on the basis of the quality of letter formation employed in the two selections.

In the conduct of the investigation the subjects showed such a high degree of consistency of performance in reading this paragraph (with poor letter formation) that no subjects beyond Subject 20 read this selection. Table IX shows data for the twenty subjects who read this selection.

For Selection 3 the average number of words read per fixation is 0.8, the average duration of the fixations is 6.4 twenty-fifths second, and the average number of words read per regression is 4.3.

Since only twenty subjects read Selection 3 it will be necessary, in comparing the records of readers for Selection 2 and Selection 3, to include the records of only the first twenty subjects in Table VII. For Subjects 1 to 20 for Selection 2 (Table VII) the average number of words read per fixation is 1.0, the average duration of fixations is 6.3 twenty-fifths second, and the average number of words read per regression is 17.7.

Poor letter formation reduces the average number of words read per fixation from 1.0 for normal handwriting to 0.8, for all subjects. The subjects use a narrower eye-span in reading the material with poor letter formation. Three subjects show no change in eye-span for the selection with poor letter formation, since the average number of words read per fixation is the same for both Selection 2 and Selection 3. All other subjects

¹⁰ Cf. *supra*, p. 7.

show a consistently smaller number of words per fixation for handwriting with poor letter formation. The decrease varies from 0.1 to 0.3 words per fixation for each subject. No subject shows a larger average number of words per fixation for the selection with poor letter formation.

The average duration of fixations for the selection with poor letter formation varies only slightly from the average duration of fixations for the selection of normal handwriting, with 6.3 twenty-fifths and 6.4 twenty-fifths, respectively, for the two selections. Four subjects use fixations of the same durations for both selections, nine subjects use longer fixations, and the other subjects use fixations of shorter average duration in reading the selection with poor letter formation. The subjects do not show any consistent trend in the duration of their fixations. The reading of handwriting with poor letter formation does not equally affect the fixation time for all subjects, when compared with the fixation time for normal handwriting.

In comparing Selection 2 with Selection 3 with respect to regressive movements it is clear that poor letter formation increases the number of regressions. The average number of words read per regressive movement for

twenty subjects for Selection 3 is 4.3, compared with 17.7 for the same subjects for Selection 2. Not only is the average number of words decreased for the selection with poor letter formation, but there is also a consistent decrease when the records of individual subjects are considered. Every subject shows a smaller average number of words per regression for the selection with poor letter formation, when compared with normal handwriting. Poor letter formation increases the number of regressive movements for every subject.

SPACING AND LEGIBILITY

In order to study the effect of spacing on the legibility of handwriting, four selections were read by the subjects: (1) Selection 4, in which the spacing was reduced between the letters, and also between the words; (2) Selection 5, in which the spacing was reduced between the letters, but normal spacing was kept between the words; (3) Selection 6, in which normal spacing was kept between letters and words, but narrower spacing (one-fourth inch) was used between the lines of handwriting; (4) Selection 7, in which the spacing was increased between letters and between words. Each selection will be considered, in turn, in order to discover the effect

TABLE IX

NUMBER OF FIXATIONS, AVERAGE NUMBER OF WORDS READ PER FIXATION, AVERAGE DURATION OF FIXATIONS, AND AVERAGE NUMBER OF WORDS READ PER REGRESSION FOR SELECTION 3

Subject Number	Number of Fixations	Average Number of Words Read per Fixation	Average Duration of Fixations	Average Number of Words per Regression
1	53	0.8	7.0	2.7
2*	40	0.9	5.5	18.5
3	54	0.8	7.0	2.8
4	45	0.9	5.9	6.1
5	52	0.8	6.2	2.8
6	41	1.0	7.6	5.4
7	38	1.1	7.2	10.8
8	38	1.1	5.0	21.5
9	44	0.9	6.5	5.4
10	45	0.9	6.8	6.1
11	66	0.6	6.0	4.3
12	44	0.9	5.8	14.3
13	67	0.6	5.8	2.1
14	44	0.9	7.0	6.1
15	53	0.8	5.7	2.8
16	41	1.0	5.9	8.6
17	51	0.8	6.0	4.3
18	56	0.8	6.5	3.0
19	75	0.6	6.4	1.9
20	62	0.7	7.1	4.3
Total	1009	---	---	---
Mean	50.4	0.8	6.4	4.3

* Record is for six lines.

of each spacing on the ease with which subjects can read the handwriting.

How is the legibility of handwriting affected, if the spacing is altered? Comparison of the selection of normal handwriting with other selections in which only the spacing has been modified, shows these results.

1. When spacing is reduced between letters and between words: The reduction of spacing shortens the line of handwriting and permits the subject to read a significantly larger average number of words per fixation than in normal handwriting. The average duration of fixations does not show any significant change when the spacing is reduced. The average number of words read per regression shows some reduction in reading the shortened line, but the difference is not significant. The reduction of spacing does make handwriting more legible, by increasing the number of words per fixation.

2. When spacing is reduced between letters, but normal spacing is maintained between words: The reduction in spacing increases significantly the average number of words read per fixation. The duration of fixations does not show any significant change. The average number of words per regression does not show any significant change. Decreasing the spacing results in improvement in legibility over normal handwriting, by increasing the average number of words per fixation.

3. When spacing is reduced to $\frac{1}{4}$ " between the lines of handwriting: There is no significant change in legibility. The ease with which the handwriting can be read is not conditioned by the spacing between lines. Handwriting with $\frac{1}{4}$ " spacing between the lines is as easily read as the handwriting with $\frac{5}{8}$ " spacing. The average number of words read per fixation, the duration of fixations, and the average number of words read per regression show that subjects read one selection as well as the other, when normal handwriting with the two spacings is compared.

4. When spacing is increased between the letters and between the words: There is a significant decrease in the average number of words read per fixation, and in the average number of words read per regression. It is clear that the legibility of handwriting decreases when the spacing between letters and between words is increased.

Compactness in the line of handwriting increases legibility of handwriting, but lack of compactness in handwriting decreases legibility.

SLANT AND LEGIBILITY

Selection 9, written with irregular slant of letters is comparable to Selection 2 in all respects except the slant. Table IV shows variation in the amount of slant for Selection 9 compared with all other selections used in this study.¹¹ The slant of the letters in Selection 2 varies from 71 to 90 degrees with the base line of writing. The slant of the letters in Selection 9 varies from 54 to 114 degrees with the base line of writing.

The data for the subjects will be analyzed to discover what effect the irregularity of slant has on the legibility of the handwriting.

Table X presents the data for the reading records of the thirty-five subjects who read Selection 9.

Table X shows for all subjects an average of 1.0 word read per fixation, with a range from 0.8 to 1.4. The average number of words read per fixation is the same as for normal handwriting, but only four subjects have the same average for Selection 9 and for Selection 2. Eighteen subjects have a larger average number of words read per fixation for Selection 9, and eleven have a smaller average for Selection 9. The average number of words read per fixation is not consistently larger for all subjects in reading Selection 9.

The average duration of fixations for all subjects is 5.9 twenty-fifths second for Selection 9, compared with 6.0 for Selection 2, normal handwriting. Not all subjects show consistently a longer average duration of fixations for one selection. Four subjects have the same average duration of fixations for both selections, eleven have a larger average duration of fixations for Selection 9, and the remaining subjects have a longer average duration of fixations for normal handwriting. The slight difference in average duration—0.1 twenty-fifths second—does not indicate any great difference in reading difficulty in the two selections.

The average number of words read per regressive movement for all subjects is 7.8, compared with 10.1 for the selection of normal handwriting. No subjects show the same average number of words per regressive movement for both Selection 9 and Selection 2.

¹¹ Cf. *supra*, p. 10.

TABLE X

NUMBER OF FIXATIONS, AVERAGE NUMBER OF WORDS READ PER FIXATION, AVERAGE DURATION OF FIXATIONS, AND AVERAGE NUMBER OF WORDS READ PER REGRESSION FOR SELECTION 9

Subject Number	Number of Fixations	Average Number of Words Read per Fixation	Average Duration of Fixations	Average Number of Words per Regression
1	48	0.9	5.8	3.2
2	39	1.1	4.9	14.0
3	39	1.1	6.9	8.4
4	35	1.2	5.1	14.0
5	39	1.1	6.1	7.0
6	34	1.2	7.9	21.0
7	29	1.4	6.6	21.0
8	33	1.3	5.0	42.0
9	37	1.1	6.5	14.0
10	36	1.1	6.4	14.0
11	42	1.0	5.1	8.4
12	45	0.9	5.1	7.0
13	68	0.6	5.7	2.2
14	36	1.1	7.4	8.4
15	31	1.3	5.7	8.4
16	36	1.1	5.7	10.5
17	45	0.9	6.2	8.4
18	47	0.9	7.2	3.5
19	46	0.9	6.2	3.8
20	46	0.9	6.3	7.0
21	33	1.3	4.9	14.0
22	38	1.1	6.4	42.0
23	41	1.0	8.3	8.4
24	39	1.1	5.6	8.4
25	36	1.1	5.4	10.5
26*	22	1.4	6.0	31.0
27	37	1.1	7.6	21.0
28	48	0.9	5.1	2.8
29	49	0.8	5.2	7.0
30	46	0.9	5.3	10.5
31	41	1.0	5.6	14.0
32	39	1.0	4.4	21.0
33	45	0.9	5.2	8.4
34	39	1.0	4.8	8.4
35	40	1.0	5.8	7.0
Total	1404	---	---	---
Mean	40.1	1.0	5.9	7.8

* Record is for five lines.

Eleven subjects show a larger average number of words read per regression for Selection 9, but all other subjects show a larger average for Selection 2. It is clear that the number of regressive movements increases when subjects read handwriting that has irregular slant.

Table XI shows data for the most effective and the least effective readers for Selection 9.

For the most effective readers the average number of words read per fixation is 1.1 compared with the average of 1.0 for the entire group of subjects. The average number of words per fixation for this same group is 1.2 for normal handwriting, indicating that the most effective readers find normal handwriting slightly easier to read than handwriting

with uneven slant. The most effective readers show an average duration of 4.6 twenty-fifths second for Selection 9, and 5.4 for Selection 2. The fixation time is shorter for the selection with irregular slant than for normal handwriting. The most effective readers have an average of 30.3 words read per regression for normal handwriting, compared with 15.8 for handwriting with irregular slant. Writing that has irregular slant is more difficult for the effective readers as judged by the average number of words read per regressive movement.

The least effective readers have an average of 0.9 word read per fixation for Selection 9, compared with 0.8 for Selection 2. The average duration of fixations is 6.4 for Selection 9,

TABLE XI

AVERAGE NUMBER OF WORDS READ PER FIXATION, AVERAGE DURATION OF FIXATIONS, AVERAGE NUMBER OF WORDS READ PER REGRESSION, FOR THE MOST EFFECTIVE AND FOR THE LEAST EFFECTIVE READERS FOR SELECTION 9

Subject Number	Number of Fixations	Average Number of Words Read per Fixation	Average Duration of Fixations	Average Number of Words Read per Regression
Most Effective Readers				
4-----	35	1.2	5.1	14.0
6-----	34	1.2	7.9	21.0
10-----	36	1.1	6.4	14.0
21-----	33	1.3	4.9	14.0
25-----	36	1.1	5.4	10.5
26-----	22	1.4	6.0	31.0
32-----	39	1.0	4.4	14.0
34-----	39	1.0	4.8	8.4
Total-----	274	9.3	44.9	126.9
Mean-----	34.2	1.1	4.6	15.8
Least Effective Readers				
3-----	39	1.1	6.9	8.4
13-----	68	0.6	5.7	2.2
16-----	36	1.1	5.7	10.5
18-----	47	0.9	7.2	3.5
19-----	46	0.9	6.2	3.8
20-----	46	0.9	6.3	7.0
23-----	41	1.0	8.3	8.4
30-----	46	0.9	5.3	10.5
Total-----	359	7.8	51.6	53.9
Mean-----	44.9	0.9	6.4	6.9

compared with 6.5 for Selection 2. The average number of words read per regressive movement is 6.9 for Selection 9, compared with 8.4 for Selection 2. The least effective readers show little difference in the records for normal handwriting and the selection with irregular slant. Irregular slant apparently does not alter the reading procedures of ineffective readers to any noticeable degree.

SUMMARY

The foregoing study of reading records for the different selections of handwriting may be briefly summarized.

1. Handwriting is less legible than printed material. In printed material the spacing between words is regular, and the length of lines can be regulated to make one line as long as every other line. The height and form of a letter in a certain style of print is always uniform, no matter how often the letter occurs on the page, or in what combination with other letters. In handwriting the spacing between letters varies to some degree, and the length of all lines is not exactly the same. The height of letters varies even in one word where the same letter may be repeated. The

form of letters varies to some extent also. These factors do not vary separately in normal handwriting, but when one factor varies it is quite likely that other factors will also show some degree of variation. For that reason the legibility of letters is not always uniform throughout any selection of handwriting. Therefore the average performance must be used in a consideration of handwriting. Analysis of the data for the selection of print and the selection of normal handwriting show that handwriting is less legible than print. The relationship is consistent, measured by the average number of words per fixation, the average duration of fixations, and the average number of words read per regressive movement.

Table XII shows for all subjects the average number of words read per fixation, the average duration of fixations, and the average number of words read per regression for each selection used in this study.

2. Good letter formation is the most important factor in determining the legibility of handwriting. Conversely, poor letter formation reduces legibility more than any other single factor considered in this investigation.

TABLE XII

AVERAGE NUMBER OF WORDS READ PER FIXATION, AVERAGE DURATION OF FIXATIONS, AND AVERAGE NUMBER OF WORDS READ PER REGRESSION FOR SELECTIONS 1 TO 11

Selection	Average Number of Words Read per Fixation	Average Duration of Fixations	Average Number of Words Read per Regression
1-----	1.4	6.5	19.4
2-----	1.0	6.0	10.1
3-----	0.8	6.4	4.3
4-----	1.1	6.0	9.2
5-----	1.0	6.1	9.7
6-----	1.0	5.8	8.0
7-----	0.8	6.2	4.4
8-----	1.1	5.9	11.4
9-----	1.0	5.9	7.8
10-----	1.0	5.8	8.6
11-----	1.1	6.0	8.8

When handwriting has poor letter formation the reader must pause frequently in the line, because the words are not recognized in large wholes. Words are perceived when the eye is at rest, and the eye pauses in the line in order that perception may take place. At each pause the reader perceives groups of letters. If the letters are poorly formed he recognizes them less easily, consequently the units of recognition become smaller, and the number of fixations per line increases. Table XII shows clearly the effect of poor letter formation, with 0.8 word read per fixation for Selection 3, characterized by poor letter formation.

Other evidence of the reduction of legibility when poor letter formation is found in handwriting is furnished by the duration of the fixations. The duration of the fixations is an index to the speed with which the reader recognizes words. If the reader has rapid recognition the pauses are short in duration. In reading the selection with poor letter formation the duration of fixations is longest

for all handwriting selections used in this study. The subjects recognize the words least rapidly in this selection.

If material is legible the reader can recognize the written words in the lines with few fixations, and the movement of the eye is from left to right, without the necessity of backward movement. When the handwriting has poorly formed letters the number of words recognized per regression decreases. Table XII shows that Selection 3 has the smallest average number of words read per regression. The data in Table XII show clearly that poor letter formation reduces legibility of handwriting.

Selection 2, normal handwriting, was compared with all other selections used, by means of Fisher's t-test. A summary of all comparisons is given in Table XIII, with reference to the average number of words per fixation, average duration of fixations, and average number of words per regression.

There is greater difference between the selections in the number of words per fixation

TABLE XIII

COMPARISON OF SELECTION 2, NORMAL HANDWRITING, WITH ALL OTHER SELECTIONS, FOR t-TEST

Selections Compared	Average Number of Words per Fixation		Average Duration of Fixations		Average Number of Words per Regression	
	t	P	t	P	t	P
2 minus 1-----	-8.40	<.01	-3.196	<.01	-4.48	<.01
2 minus 3-----	5.745	<.01	.5304	.6 <P<.7	6.032	<.01
2 minus 4-----	-3.5926	<.01	.7923	.5 <P<.6	-.3659	.8 <P<.9
2 minus 5-----	-2.430	.01 <P<.02	.546	.6 <P<.7	-.3691	.8 <P<.9
2 minus 6-----	.1206	>.9	1.571	.2 <P<.3	1.5369	.2 <P<.3
2 minus 7-----	3.8745	<.01	0.00	-----	3.18	<.01
2 minus 8-----	-2.253	.02 <P<.05	1.54	.2 <P<.3	-1.5970	.2 <P<.3
2 minus 9-----	-.522	.7 <P<.8	.616	.6 <P<.7	3.53	<.01
2 minus 10-----	-1.7024	.05 <P<.1	2.548	.01 <P<.02	1.9700	.02 <P<.05
2 minus 11-----	-2.7666	<.01	0.00	-----	.0855	>.9

than in the other criteria used. Of the ten comparisons with Selection 2 seven significant ratios occur, one is of questionable significance, and only two are too small to have significance. The variations in handwriting produce significant changes in the number of words read per fixation, compared with normal handwriting. The variations in handwriting do not produce a corresponding change in the average duration of the fixations. Of the ten ratios shown in Table XIII only two are significant. The variations in handwriting result in significant change in the average number of words read per regression. Of the ten ratios five are significant. Variation from normal handwriting did not produce any significant difference, judged by the average number of words read per regression.

3. The compactness of handwriting affects its legibility. Reduction of spacing between letters and between words appears to improve legibility, but the evidence is not conclusive. The reduction of space shortens the line of writing, and results in a decrease in the number of fixations necessary in reading the shortened line. The average number of words read per fixation is increased significantly. The average duration of fixations is decreased, but the decrease is not significant in amount. The average number of words read per regression shows also a slight increase, but not enough to be significant.

Reduction of spacing between letters only, with no reduction between words, shows the same tendency as the reduction of spacing between words and between letters. The average number of words per fixation is increased over the number in normal handwriting, but there is no significant change in the average duration of fixations or in the average number of words read per regression. The reduction of spacing between letters only probably does increase legibility, but the data are not conclusive.

Reduction of spacing from $\frac{5}{8}$ " to $\frac{1}{4}$ " between lines does not noticeably affect the legibility of handwriting. Reference to Table XIII shows that the difference between normal handwriting and handwriting with the narrower spacing (Selection 2 and Selection 6) is too slight to have any significance.

Increasing the spacing between words and between letters reduces legibility. The increase in spacing results in a longer line, which in turn increases the number of fixa-

tions. The number of words per fixation is perceptibly and significantly decreased. The average duration of fixations remains exactly the same as for normal handwriting. The average number of words read per regression is significantly decreased. The selection with wide spacing between letters and between words ranks next to the selection with poor letter formation in illegibility.

Compactness in handwriting favors legibility and lack of compactness decreases legibility. The compactness results from decreasing the spacing between the letters and between words: it does not result from a crowding of the letters, or from changing the style of letters in the handwriting. A change in the size or style of letters might show a different result, but this aspect of writing was not investigated in the present study.

4. Evenness of alinement apparently is not an important factor in the legibility of handwriting. Comparison of the results of reading a paragraph with poor alinement and one with good alinement shows that poorly alined handwriting is not less legible than handwriting with good alinement. The poorly alined paragraph shows a significantly larger average number of words read per fixation than does the selection of normal handwriting. When the two paragraphs are compared there is no significant difference in the average duration of fixations, and in the average number of words read per regression. Word recognition is more rapid in the selection of uneven alinement.

5. The regularity of the slant of letters is an important factor in the legibility of handwriting. When the slant of the letters becomes irregular the legibility of handwriting is decreased. Irregular slant does not result in any marked change in the number of words read per fixation. The average duration of fixations is not altered to any significant extent by irregularity of slant, and the records show an average duration of fixations that differs in no significant way from the average duration of fixations from normal handwriting. Handwriting that has irregular slant does show a decrease in the average number of words read per regression. Since regressions occur only as an index of difficulty for the reader, it is evident that irregular slant does decrease the legibility of handwriting. No attempt was made in this study to determine what slant is best, with respect to

legibility, but the data do show that the irregularity of slant does decrease the legibility of handwriting.

6. The results of this investigation are inconclusive, with respect to the influence of weight of line on legibility of handwriting.

A heavy line produces handwriting that is probably more legible than handwriting produced with a medium line. The difference between handwriting produced with a heavy line and handwriting produced with a medium weight of line is doubtful, when judged by the average number of words read per fixation. The number of words is somewhat larger for the selection with the heavier line, but since *P* lies between .05 and .1, according to Fisher's *t*-test, the difference cannot be said to be significant. There is a difference in the average duration of fixations for the selection with a heavy line and the selection with medium weight of line, with the longer duration for the heavy line. The average number of words read per regression is larger for normal handwriting than for the handwriting produced with the heavy line. It cannot be definitely stated that a heavy line produces more legible handwriting.

Handwriting that is characterized by a light line is more legible than handwriting that has a medium weight, when judged by the average number of words read per fixation, and the difference is significant. The average duration of fixations for the two selections is exactly the same, showing no difference between the two selections. The average number of words per regression is slightly more for the selection with medium weight, but the difference is very small—not large enough to have any significance. It cannot be stated that the use of a light line in handwriting is an important factor in the legibility of handwriting.

Determination of the effect of weight of line on legibility is not clearly shown in the results of this investigation. Further study is needed to clarify the issue of weight of line and its effect on legibility of handwriting.

IMPLICATIONS

Several implications for the teaching of handwriting grow out of the results of this investigation.

1. No one characteristic of handwriting exists separately from other characteristics, but they are interrelated in the handwriting

process. In any attempt to improve the quality of handwriting it is necessary to keep clearly in mind the fact that one characteristic is dependent on others. Letter formation is closely related to spacing, slant, alignment, and weight of line. Any change in one characteristic is accompanied by a corresponding change in the others.

2. Since letter formation is the most important factor in determining the legibility of handwriting, this aspect of writing should receive the greatest emphasis in teaching children to write.

In recent years handwriting instruction has emphasized the use of simplified letter forms, free from flourishes and extra strokes, containing only the essentials of the letters. The results of this study indicate that, from the point of view of legibility, this emphasis is correct.

In teaching children to write, the development of good letter formation should be the chief outcome, and the development of other characteristics should be related to the improvement of letter formation. The chief concern of teachers should be the improvement of other aspects of the handwriting process only as they contribute to good letter formation—not as ends in themselves. Slant, alignment, spacing, and quality of line should receive attention only as they improve letter formation. Principles that result in improvement of letter formation are probably reliable guides to teachers in improving handwriting.

3. Pupils should be taught to use a compact type of handwriting. This should not be developed at the sacrifice of good letter formation, but should emphasize compactness of spacing between letters. A medium or narrow spacing between letters is to be preferred to wide spacing between letters. Since the use of wide spacing in handwriting can develop into a type of writing which results in malformation of letters or in the development of flourishes, pupils should be taught in such a manner that correct letter formation is used even with relatively narrow spacing between letters.

It need not be a matter of concern whether or not children use a particular width of ruling on paper. There is no difference in the legibility of handwriting with $\frac{5}{8}$ " and $\frac{1}{4}$ " between the lines of writing. The selection of either ruling should be made on the basis of other factors than the legibility of handwriting.

ing, since legibility is not modified by the use of either spacing.

4. Evenness of alinement need not receive special emphasis in the teaching of handwriting. Uneven alinement adds slightly to the legibility of handwriting, but is not of sufficient importance to be considered as an end in itself. If correct letter formation is emphasized sufficiently in the teaching of handwriting, the letters will be well alined. Uneven alinement is likely to be caused by poor letter formation. For that reason it is not desirable to teach children to write with uneven alinement. It is quite probable that, aside from a possible esthetic effect, no end is served by insisting that handwriting be perfectly alined. If good letter formation is set up as the chief outcome of handwriting instruction even alinement will probably be an accompanying result. Handwriting of good quality is produced by rhythmic movements of the hand and forearm, and even alinement is a natural outcome of rhythmic movements in the writing process.

5. The regularity of slant is important as a component of legibility of handwriting. It is important, therefore, if the writing is to be legible, that the slant of writing be more or less uniform. Uniformity of slant is closely related to good letter formation in the writing process. No attempt was made in this study to determine what slant is best for the sake of legibility, but the investigation does show that the regularity of slant is important. The teaching of handwriting, therefore, should

emphasize regularity of slant as an important item. The slant of handwriting is conditioned by the muscular control and skill of the writer. Teachers should emphasize regular slant as an important aspect of correct letter formation in order to increase the legibility of handwriting.

6. The weight of line employed in handwriting is not an important matter, judged from the point of view of legibility. It is probably best that children should use a medium weight of line. Neither a heavy line nor a light line is clearly superior to a medium weight with respect to legibility. The manipulation of a medium weight of pen is probably more satisfactory, from the point of view of the pupil who is learning to write, than is the use of a fine pen or a coarse pen. Since there is no clear-cut case for either the light or the heavy pen, it is probably best to use a pen of medium weight.

7. Handwriting has social value only as it provides a more or less permanent record which can be read by someone. Children should be made aware of the necessity for producing a legibly written record, and should be made to understand the extent to which the different characteristics of handwriting enter into the composite characteristic designated as legibility. Slant, alinement, and the other characteristics should receive attention, not as important outcomes in themselves, but because they contribute to improved legibility of the handwriting.

